

The Status of Water Quality in Arizona – 2002

Volume II. Studies and Analyses of Watersheds Related to the 2002 305(b) Report and the 303(d) List



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Prepared by:
Diana Marsh

Editing and assistance: Nancy LaMascus, Steve Pawlowski, Kris Randall, and Linda Taunt

Graphic assistance: Lisa Rowe and Danese Cameron

Database assistance: Chris Conneran, and Eileen McMullen

Groundwater analysis: Doug Towne

Surface water assessments: Mathew Barry, Julie Collins, Max Enterline, Cheri Horsley, Robert Mills, and Jeffrey Servoss

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Elizabeth Boettcher, Susan Fitch, Rebecca Followill, Jennifer Hickman, Lee Johnson, Sara Konrad, Lin Lawson, Angela Lucci, Doug McCarty, Chris Notgrass, Kyle Palmer, Matt Oller, Greg Olsen, Samuel Rector, Amanda Ryan, Robert Scalamera, Patti Spindler, Doug Towne, and R. Scott Williams

Arizona Department of Environmental Quality
1100 West Jefferson Street
Phoenix, Arizona 85007
(602) 771-2300
In Arizona 1-800-234-5677
TTD (602) 771-4829

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Scope and Purpose of Volume II

Volume I provides what is essentially required to fulfill mandates in the Clean Water Act section 305(b) and 303(d). It included the following information:

- General background information;
- Terms and abbreviations used in this report;
- A description of the assessment and listing process, including statutes, rules, and standards governing this process;
- A summary and interpretation of assessments, including the five-part assessment list;
- The status and recommendation of waters on the 1998 303(d) List;
- The proposed 2002 303(d) List of impaired waters, including priority and scheduling of the TMDL;
- An overview of ground water quality in Arizona; and
- A description of key programs involved in assessment and remediation of water quality problems, including the monitoring program.

Volume II documents the data analyses for the assessments and listing actions in Volume I. It also provides the watershed context for these assessments, including descriptions of research being conducted that may influence these and future assessments. Volume II provides the following information:

- The watershed approach to water quality management;
- Watershed improvement funds available;
- Water quality research occurring in Arizona;
- Watershed discussions of water quality, including:
 - < General watershed information,
 - < Monitoring data available for each surface water,
 - < Surface water assessments, and impaired waters identification.
 - < Ground water quality information, maps, and tables
 - < Studies and water quality improvement activities.

Volume I and Volume II are intended to be used together and not as separate reports; therefore, information is not repeated in these volumes. To understand information in Volume II, the reader will need to refer to the assessment and listing process, rules, abbreviations, and standards provided in Volume I. References for both volumes are provided in Volume II, where the bulk of the citations are made. This report has been split into these two volumes primarily because of the size of the report.

What is Arizona's Watershed Approach?

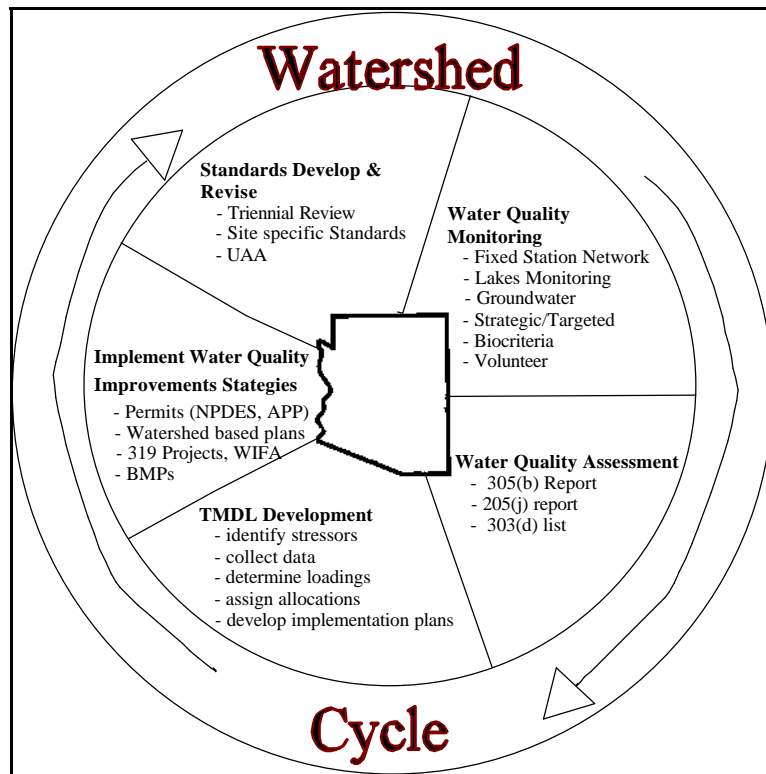


Figure 1. Watershed Cycle

1997, ADEQ drafted *The Arizona Statewide Watershed Framework* that described planning and management activities that could be integrated to address water quality issues on a watershed basis using a watershed management cycle (**Figure 1**). Each of the ten watersheds identified in Arizona (**Figure 2**) would have a sequence of programs and activities occurring in an iterative manner.

Some of ADEQ's water quality programs readily fit this watershed focused approach, while others do not. For example, ambient water quality monitoring becomes more efficient by focusing resources on one watershed at a time; however, initial permits must be issued as needed and cannot be delayed until the focus watershed is active. Once issued, permits can be scheduled for renewal

based on a watershed rotation. ADEQ believes the watershed approach is improving efficiency, increasing inter-agency and intra-agency communication, and maximizing resources. Activities where the watershed approach is actively being used by ADEQ include:

- Ambient surface water quality monitoring (see Chapter VII in Vol. 1);
- Assessment of water quality conditions;
- Participation in locally-led watershed groups to identify and address water quality and quantity issues;
- Implementation of Water Quality Improvement Grants;
- Collaboration with local watershed groups to develop watershed-based plans; and
- Renewal of surface water discharge permits (NPDES/AZPDES).

The schedule for watershed activities is shown in **Table 1**.

Table 1. Watershed Focus Activities

Watershed	Monitoring	NPDES/AZPDES Permit
Bill Williams	2003, 2008, 2013	1996, 2001, 2006
Colorado-Grand Canyon	2004, 2009, 2014	2000, 2005, 2010
Colorado-Lower Gila	2003, 2009, 2013	1996, 2001, 2006
Little Colorado-San Juan	2001, 2006, 2011	1999, 2004, 2009
Middle Gila	2002, 2007, 2012	1996, 2001, 2006 Agua Fria, Hassayampa 1997, 2002, 2007 Granite Reef to Painted Rock 1998, 2003, 2008 Coolidge Dam to Salt River
Salt	2002, 2007, 2012	1998, 2003, 2008
San Pedro - Willcox Playa-Rio Yaqui	2000, 2005, 2010	1999, 2004, 2009
Santa Cruz-Rio Magdalena-Rio Sonoyta	2001, 2006, 2011	2000, 2005, 2010
Upper Gila	2000, 2005, 2010	2000, 2005, 2010
Verde	1999, 2004, 2008	1999, 2004, 2009



Figure 2. Arizona's Watersheds

What is a Watershed-based Plan and why develop one?

States, territories, and tribes were directed by EPA's Clean Water Action Plan of 1998 to develop and implement action strategies for watersheds not meeting clean water and other natural resource goals. The plans to restore surface waters within a given watershed were known as Watershed Restoration Action Strategies (WRAS). The focus of these plans have been expanded to include preventative measures to minimize discharges of nonpoint source pollution, and have been renamed as Watershed-based Plans.

EPA envisioned that the state, territory and tribal agencies would work collaboratively with private-sector organizations and concerned citizens to develop effective and cost efficient ways to implement strategies, and thereby restore the health of watersheds.

As directed by the Clean Water Action Plan, Arizona developed a Unified Watershed Assessment in 1998, and prioritized Arizona's 84 eight-digit Hydrologic Unit Code (HUC) "watersheds" from greatest environmental resource concern to the least. Four assessment categories were used to classify Arizona watersheds, including:

- Category I In need of restoration,
- Category II In need of preventive action,
- Category III Pristine or sensitive aquatic systems, or
- Category IV Insufficient data to assess.

Since 1998, several Watershed-based Plans have been completed (**Table 2**). ADEQ uses this planning process to identify areas for watershed improvement projects and to build more effective watershed partnerships. Proposed water quality improvement projects with a detailed watershed-based assessment and plan can more efficiently identify the scope and details of watershed improvement needs to facilitate obtaining funds for watershed improvements (see the following Water Quality Improvement Grants discussion).

ADEQ has identified six critical elements for an acceptable Watershed-based Plan or a similar planning document. Equivalent plans could include a TMDL report, Forest Management Plans and other planning documents, as long as the document successfully addresses the six critical elements identified below:

- Identification of specific water quality and natural resource problems that need to be addressed, including the sources of pollution and the relative contribution of nonpoint source pollution for TMDL studies.
- A detailed description of the restoration actions that should be taken to achieve desired water quality and natural resource goals and outcomes. These include implementation strategies identified for TMDL studies.
- Monitoring and evaluation activities that define water quality problems or assess progress toward achieving water quality and natural resource goals.
- Funding needs and sources to support the implementation and maintenance of restoration measures.
- A schedule for implementation of needed restoration measures and identification of appropriate lead agencies and community oversight for implementation, maintenance, monitoring and evaluation of improvement projects.
- Public outreach methods that will be used to engage and maintain local community and government involvement.

Table 2. Status of Watershed-based Plan Development

WATERSHED	WATERSHED-BASED PLAN DEVELOPMENT
Bill Williams	
Colorado-Grand Canyon	Northwest Arizona Watershed Council -- under development
Colorado-Lower Gila	
Little Colorado-San Juan	Upper Little Colorado River (LCR) Watershed Partnership – drafted LCR Multi-Objective Management Group (MOM) – <u>adopted</u>
Middle Gila	Tres Rios River Management Group – <u>adopted</u> Upper Agua Fria Watershed Partnership – <u>adopted</u>
Salt	Lower Verde-Lower Salt Watershed Advisory Group – <u>adopted</u>
San Pedro-Willcox Playa-Rio Yaqui	Middle San Pedro Partnership – under development Upper San Pedro Partnership – draft
Santa Cruz-Rio Magdalena-Rio Sonoyta	
Upper Gila	Upper Gila Partnership – <u>adopted</u>
Verde	Oak Creek Canyon Task Force – draft Verde Watershed Association – <u>adopted</u>

By involving local communities, tribes, and private-sector organizations,

Arizona is focusing and prioritizing restoration activities to achieve demonstrable improvements in water resources, aquatic ecosystems and watershed health. More information is at:

<http://www.adeq.state.az.us/comm/download/water>.

What funds are available to implement strategies?

Numerous funding sources can be used for projects that improve water quality in Arizona. Three of those funds include:

- Water Quality Improvement Grants, administered by ADEQ;
- Water Protection Funds administered by an ADWR commission; and
- Water Infrastructure Financing Authority.

Water Quality Improvement Grants –The Water Quality Improvement Grant Program distributes grant funds under Section 319(h) of the federal Clean Water Act to both public and private entities within Arizona. These grants are to implement on-the-ground water quality improvement projects that address nonpoint sources of pollution. Project summaries of Water Quality Improvement Grant projects are included in the watershed discussions in this volume of the report.

Grant applications that contain activities identified in a Watershed-based Plan (or equivalent plan) are given priority over other projects.

For a grant application to be considered eligible for evaluation, the application must comply with the process described in the current *Water Quality Improvement Grant Program Manual*, and the project description must indicate how all of the following will be accomplished:

- Improve, protect or maintain a surface water in Arizona by addressing a nonpoint source of pollution;
- Demonstrate acceptable water quality management principles, sound design, and appropriate procedures;
- Yield benefits to the state at a level commensurate with project costs;
- Have an on-the-ground implementation component within Arizona;
- Provide for at least 40% of the project costs as non-federal match;
- Support the ADEQ, Water Quality Division Mission; and
- Be eligible under applicable state and federal regulations.

The Water Quality Improvement Grant Manual provides details about the grant

program and includes the application forms. For more information about the Water Quality Improvement Grant Program or to be added to the program's mailing list, please contact the program at (602) 771-4635 or toll free in Arizona, (800) 234-5677, Ext. 4635, or email at: ward.susan@ev.state.az.us or on the web site at: <http://www.adeq.state.az.us/environ/water/mgmt/planning>.

Watershed Protection Funds – In 1994, the Arizona Water Protection Fund was established to implement projects that would maintain, enhance, and restore rivers, streams, and associated riparian resources, including fish and wildlife that are dependent on these habitats. In previous years, the legislature has provided \$5,000,000 annually in grants to fund proactive incentives to implement water quality and water quantity restoration actions. However, in 2002, funding was limited to \$500,000 due to deficits in the state budget.

Any individual, entity, state or federal agency, or political subdivision of Arizona may submit an application to the Arizona Water Protection Fund Commission. Project summaries of Water Protection Fund projects are included in the watershed discussions in this volume of the report. A list of projects currently funded is published annually (ADWR, 2000). For further information, please contact the commission at (602) 417-2400 extension 7016.

Water Infrastructure Financing Authority – Political subdivisions may obtain these funds to finance the following types of water quality improvement projects:

- The design, construction, improvement, or refinancing of publicly owned treatment facilities that are consistent with the areas water quality management plans (208 plans); or
- A nonpoint source implementation project. Projects can include training and public education, development of pollution source reduction management practices (Best Management Practices), demonstration projects, or other activities associated with the control of nonpoint sources of pollution.

What Water Quality Research is Occurring In Arizona

A number of research efforts have looked or are looking at regional water quality concerns. Other significant national studies and guidance documents of regional importance are also cited in this section. These studies discussed here are not limited to a single watershed or ground water basin. Studies conducted within a specific watershed are summarized in the watershed discussions that follow.

Biocriteria Development for Arizona – ADEQ has been developing methods for assessing the biological integrity of perennial, Wadeable streams in Arizona since 1992. According to recently updated EPA Rapid Bioassessment Protocols (USEPA, 1999c), regional reference conditions should be developed first to establish one or more index of biological integrity.

An Index of Biological Integrity

Biological integrity is the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms, having a species composition, diversity, and functional organization comparable to that of the natural or least impacted habitat of the region. This least impacted diversity becomes the primary reference condition used to measure and assess water quality. "Reference conditions" are then a composite of community characteristics for least impacted (reference) sites within a region.

A macroinvertebrate index of biological integrity is calculated based on a variety of quantified biological attributes that measure community structure, function and tolerance (e.g., total taxa richness, percent composition by individuals in the scraper feeding group, or overall community tolerance). Using the appropriate index of biological integrity, the biological integrity of a site can be determined by comparing its community characteristics to those of the reference community.

Currently a warm water and a cold water community index have been established for perennial, Wadeable streams. Indexes for other surface water types may eventually be developed.

The following reports have been produced by this program and can be obtained by contacting ADEQ at (602) 771-4543 or -4219:

- *Using Ecoregions for Explaining Macroinvertebrate Community Distribution Among Reference Stream Sites in Arizona* (ADEQ, 1996b) critiques the use of ecoregions and indicates alternative classification systems based on elevation may provide better differentiation among

reference communities in Arizona.

- *Macroinvertebrate Community Distribution Among Reference Sites in Arizona* (ADEQ, 2001a) describes a regional reference site approach based on a warm water community (below 5000 feet elevation) and a cold water community (above 5000 feet elevation).
- *Biocriteria Program Quality Assurance Program Plan (QAPrP)* (ADEQ, 2001b). This document establishes the bioassessment methods and protocols ADEQ is following and one that would meet credible data requirements established in the new Impaired Waters Identification rules. Methods for measuring physical-habitat to support bioassessment are also included in this document.
- *Development and Testing of a Biological Index for Warmwater Streams in Arizona* (Gerritsen and Leppo, 1998). A warm water macroinvertebrate community biological index is established for perennial, Wadeable streams below 5000 feet elevation.
- *Development and Testing of a Biological Index for Coldwater Streams in Arizona* (Leppo and Gerritsen, 2000). A cold water macroinvertebrate community biological index is established for perennial, Wadeable streams above 5000 feet elevation.

Physical Integrity Assessment Methods Development – The objective of the federal Clean Water Act is to "restore and maintain the chemical, physical, and biological integrity of the Nation's waters."

Physical Integrity

Physical integrity in streams can be defined as the dynamic stability of a stream channel. Stream stability is defined as the ability of a channel to carry the water and sediment of its watershed while maintaining its dimension, pattern, and profile without aggrading or degrading over time (Leopold, 1994). As streams go through a natural cycle of aggradation (accumulation) and degradation (erosion) and lakes naturally accumulate sediment, acceptable physical integrity will probably eventually be defined by the speed of the process and resource management goals for that surface water. Currently, ADEQ is developing methods to accurately measure characteristics of physical integrity.

Arizona's current standards are primarily based on measurement of chemical conditions. To initiate development of meaningful physical integrity criteria

ADEQ is performing geomorphic surveys on streams. This research has focused on:

- Developing regional curves to estimate bankfull stage by correlating watershed size with stream hydraulic measurements such as cross sectional area, average depth, width and discharge at bankfull stage;
- Testing Rosgen's (1996) Bank Erodibility Hazard Index (BEHI) (the potential for a stream bank to erode) for application in Arizona;
- Creating sediment rating curves to evaluate excess sediment loads in reference versus impacted streams.

Over the past decade, a system for classifying and assessing rivers has been developed by Rosgen (1996). By identifying bankfull stage, waters can be classified into one of seven stream types using Rosgen's methods. These classification and assessment methods are being applied to Arizona's streams by ADEQ, the U.S. Forest Service, the U.S. Bureau of Land Management, and others.

This research has led to the publication of the following reports:

- *Analysis of Water Quality Functions of Riparian Vegetation* (Engineering Science, 1994). This is a technical review of existing scientific knowledge on the functional roles of riparian vegetation in controlling surface water quality. The report provided information about the types of water quality functions that a riparian area or wetland can provide and the characteristics of the riparian or wetland type that enables it to perform each function.
- *A Guidance Document for Monitoring and Assessing the Physical Integrity of Arizona's Streams* (Graf and Randall, 1998). This document outlines a set of basic scientific principles for understanding and describing physical integrity in terms of indicator measurements such as: channel width, channel depth, channel gradient, hydraulic roughness, flow velocity, water discharge, sediment discharge, sediment particle size, channel sinuosity, channel pattern, shear stress, stream power, and bankfull condition.
- *Regional Relationships for Bankfull Stage in Natural Channels for Central and Southern Arizona* (Moody and Odem, 1999). Sites on perennial, intermittent, and ephemeral streams in central and southern Arizona were chosen to determine the regional relationships of bankfull stage in natural channels. Bankfull discharge and channel

characteristics of width, mean depth, and cross-sectional area were plotted as a function of drainage area to create "regional curves." These regional curves can then be used to identify bankfull in any other natural channel. Bankfull determinations are necessary for surveying and classifying streams according to Rosgen (1996).

- *Draft Regional Relationships Between Hydrologic and Hydraulic Parameters in the State of Arizona* (Odem et al., draft 2001). This report integrates data collected at ADEQ's Biocriteria Program reference sites with data collected at sites in Moody and Odem's study (1999) to update Arizona's regional curves with additional data and then statistically evaluates several regional relationships.
- *Draft Bank Erosion at ADEQ Biocriteria Reference Sites in the Verde River and San Pedro River Surface Water Basins* (Odem et al., draft 2001). Bank stability and overall stream stability were evaluated for 20 biocriteria reference sites in the Verde and San Pedro surface water basins. This project was an initial test and evaluation of Rosgen's BEHI model for use in Arizona.
- *Draft Evaluation of the BEHI Bank Erosion Prediction Model in the Verde River and San Pedro River Surface Water Basins* (Odem et al., draft 2001). Bank Erosion Hazard Index data from 49 additional sites in the Verde and San Pedro surface water basins collected in 1999-2001 were added to the first 20 sites (see report above). Results indicated that Rosgen's BEHI is not an accurate predictor of short term erosion rates for these watersheds. Better results might be found over a longer time period and with more accurate near bank stress values which incorporate stream gradient.

ADEQ recently received an Arizona Watershed Protection Fund grant to determine the feasibility of developing physical integrity criteria and which indicators best describe physical conditions. The best physical integrity indicators will be later tested around the state in different ecosystems to develop universal application. Measurements to support a Bank Erosion Hazard Index, rating curves, pebble counts, bioassessments, and water quality based assessment will be collected at perennial, intermittent, and perennial sites. This work is to be completed in Cienega Creek in the Santa Cruz surface water basin. ADEQ wants to determine if regional curves hold true for non-perennial streams.

The Urban Lakes Study – The "Arizona Urban Fishing Lake Limnological

Characterization Program” was initiated by the Arizona Game and Fish Department, in cooperation with ADEQ, in December 1997. This study was prompted by the need for reliable water quality and limnological data on artificial, municipal lakes in the arid southwest. These “urban” waters receive unparalleled recreational angling use in this state.

This was a reconnaissance level survey representing limnological and water quality conditions in Arizona’s urban lakes. These baseline data are useful as baseline for future evaluation of lakes or comparison with other urban waters. Some broad management recommendations are offered based on this study, but no specific management prescriptions are provided for each lake.

To determine water quality conditions in urban lakes, target analytical groups were monitored once a quarter for one year in seven lakes: Alvord, Cortez, and Papago #3 in Phoenix, Chaparral in Scottsdale, and Kennedy, Lakeside, and Silverbell in Tucson. These lakes were chosen because they had either a history of water quality concerns or because they were representative of other shallow urban lakes.

Findings are to be published by AGFD soon. Preliminary findings include:

- These urban lakes were much higher in pH, nutrients, and chlorophyll *a* than other waters in their watersheds.
- These lakes experience seasonal extremes with respect to temperature, pH, and low dissolved oxygen that exceed the ranges for fish health and growth, and they exceed state surface water quality standards for their designated uses.
- As expected in a closed system with high evaporation and urban runoff in an arid region, these urban lakes are more saline and are moving towards a sulfa-chloride or chloride dominant water as opposed to the worldwide carbonate dominant waters.
- Based on chlorophyll *a* and algae density, these lakes are highly productive. The algal species are dynamic and opportunistic.
- Seasonal ecosystem responses to high primary production include: decreased carbonate and calcium ion levels, increased pH, erratic or depressed dissolved oxygen concentrations, and lowered levels of phosphorus in sediment and waters.
- Nuisance blooms and species of algae at several lakes are indicative of pollution and advanced eutrophication. Algae may cause odor problems, release toxins into the lakes affecting fish health, contribute

directly to fish kills due to oxygen crashes and interfere with fishing and overall aesthetics.

- Annual trends in nutrient concentrations indicate temporary summer stratification caused anoxic hypolimnetic conditions, mobilizing phosphorous concentrations from sediment to the water column. There were no seasonal trends in total nitrogen concentrations. Unionized ammonia levels approached recommended thresholds above which trout and catfish health and growth may be negatively affected.
- Urban lakes are impacted by urban runoff as evident by the concentrations of Total Petroleum Hydrocarbon in the sediment; however, bioaccumulation of this contaminant does not seem to be a concern as fish tissue lacked detectable concentrations.
- Analysis of metals in water, soil and fish tissue indicated that only beryllium exceeded a water quality standard in only one sample, while copper and cadmium concentrations in sediment were at levels EPA’s National Sediment Quality Survey for surface Waters (year) has found to have “effects that occasionally occur” and could pose a threat to aquatic wildlife. Copper sulfate is a widely used algicide and herbicide used to control algae. Cadmium may be introduced through air deposition and effluents from manufacturing operations and municipal effluents. All metal concentrations in fish tissue were below detectable levels and pose no health threats due to fish consumption.

For further info, contact Arizona Game and Fish Department’s Urban Fishery Program at (602) 789-3257 or ADEQ’s Lakes Program at (602) 771-4541.

Arid West Water Quality Research Project – Pima County is administering a major grant from EPA to develop appropriate water quality criteria for the arid and semi-arid West, and to improve the scientific basis for regulating water quality from effluent and storm water discharges for the arid and semi-arid West. The research is designed to produce results that will protect the species and habitats characteristic of ephemeral and effluent dependent stream ecosystems.

The arid and semi-arid portion of the western United States is characterized by annual precipitation totals of less than 15 inches or less. The majority of waterways south of 40° latitude are ephemeral, carrying water only in response to rainfall events. The only water present in a stream may be treated wastewater effluent. This area is delineated geographically as:

East to south-central Texas, western Montana, and Nebraska;
West to the eastern slopes of the Sierra Nevada and Cascade Ranges
along the Pacific coast;
North to the Canadian border; and
South to the Mexican border.

Flora and fauna assemblages also differ significantly from more humid regions of the United States. National water quality criteria have been developed to protect aquatic species that are not representative of species important to ephemeral and effluent-dependent streams. There is a need to develop techniques to evaluate the effects of storm water flows on the biota, and to measure the enhancement or degradation of ephemeral stream resources associated with storm water flows.

A number of research topics have been identified, and the Arid West Project has entered the research phase. Information about research topics can be obtained at the project's web site: <http://www.co.pima.az.us/www/wgrp/index.html>. Examples of this research include:

- **Extant criteria evaluation** – This project is to examine the appropriateness and potential weaknesses of applying national ambient water quality criteria, which were used to set Arizona's surface water quality standards, for arid western ecosystems. This project is to recommend future research to address these potential weaknesses.

To analyze the appropriateness of ambient water quality criteria for arid western ecosystems, three basic issues must be addressed.

- 1) What should the pollutant concentration averaging periods be for effluent dependent or ephemeral streams?
- 2) How often can a standard be exceeded and still protect the biota in these systems?
3. To what extent do water quality characteristics (e.g., pH, dissolved organic carbon, and hardness), and their variability, influence chemical bioavailability.

The criteria for the following constituents will be used as models, as they are of concern to dischargers in the arid West: copper or silver, selenium or mercury, diazinon or nonylphenol, and ammonia. Each will be reviewed with regards to the biological, physical, and chemical characteristics of arid West surface waters.

- **Habitat characterization study** – Ten sites, where treated effluents are being discharged into normally dry surface waters, have been selected to characterize aquatic and riparian habitats. Three of these sites are in Arizona. Habitats will be characterized relative to the physical, chemical, and biological constituents present upstream and downstream of the discharge points.

A report of the historic data collected at these sites has been completed. This report includes an analysis of the water quality regulatory framework affecting arid West states.

The next phase of this project will identify the following: similarities and differences among sites, a habitat classification method, and recommendations for further study.

- **Survey of municipal NPDES dischargers** – A survey of dischargers in the arid West was conducted to obtain information on the following:
 - a. Issues and problems,
 - b. discharge rates,
 - c. designated uses of receiving waters as defined in state standards, and
 - d. physical, chemical, and biological characteristics of receiving waters.

The following 17 states were surveyed through a written questionnaire and telephone conversations an: Arizona, California, Colorado, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming.

NAWQA - Central Arizona Basins Study Unit – The U.S. Geological Survey included the Central Arizona Basins Study Unit as one of 51 water quality study units in the National Water Quality Assessment (NAWQA) Program. The NAWQA Program seeks to improve the scientific and public understanding of surface and ground water quality (Gilliom et al., 1995).

The Central Arizona Basins Study Unit covers 34,700 square miles in Arizona. Water, sediment, and biological samples (e.g., animal tissue, macroinvertebrate samples) were collected in streams in urban, agricultural, forest, and rangeland areas to determine the effects of land use on water quality. At most sites, water

samples were collected monthly from late 1995 through early 1998, and at some stream sites additional samples were collected during storms to assess the effects of storm water runoff on water quality. Two sites were sampled twice monthly for 1 year to determine the occurrence and distribution of pesticides. A single round of sampling for contaminants in streambed sediment and fish tissue was completed in 1995-1996.

Ground water was also sampled to determine the effects of human activities on water quality. Three alluvial basins were monitored:

- a. West Salt River Valley,
- b. Upper Santa Cruz Basins,
- c. Sierra Vista subbasin (of the upper San Pedro).

Existing wells were monitored, except in the West Salt River Valley, where shallow monitoring wells were installed and sampled to determine the effects of irrigated agriculture on shallow ground water quality.

The analysis of this data has resulted in the publication of a series of reports that are available through the U.S. Geological Survey. To obtain copies, contact USGS in Tucson at (520) 670-6135.

- *Water Quality in the Central Arizona Basins 1995-1998* (Cordy et al., 2000) summarizes the major findings about water quality.
- *Water Quality Assessment of the Central Arizona Basins, Arizona and Northern Mexico – Environmental Setting and Overview of Water Quality* (Cordy et al., 1998). This report provides a description of the physical, chemical, and environmental characteristics that may affect water quality in the Central Arizona Basins study area and it presents an overview of surface and ground water quality.
- *Organochlorine Compounds in Streambed Sediment and biological Tissue from Streams and Their Relations to Land Use, Central Arizona* (Gebler, 2000) discusses the occurrence and distribution of organochlorine compounds (pesticides) and their relation to land use.
- *Ground Water Quality in the Upper Santa Cruz Basin, Arizona, 1998* (Coes, et al, 2000) assesses ground water quality and identifies factors affecting ground water quality in this basin. In addition, pre-existing data for six wells were analyzed to determine changes in water quality within the basin over time.
- *Ground Water Quality in the Sierra Vista Subbasin, Arizona, 1996-*

1997 (Coes, et al, 1999) assesses ground water quality in this basin, looking for statistically significant relationships between water quality and well location, well depth, aquifer type, geology, land use, and changes in water quality based on samples collected in 1950-1965.

- *Water Quality of Selected Effluent Dependent Stream Reaches in Southern Arizona as indicated by Concentrations of Periphytic Chlorophylla a and Aquatic Invertebrate Communities* (Gebler, 1998) is a short report comparing water quality in two effluent dependent waters with sites in noneffluent dependent surface waters based on levels of Chlorophyll *a* and the taxonomic composition and abundance of aquatic invertebrates.
- *Physical Habitat and Geomorphic Data for Selected River Reaches in Central Arizona Basins, 1995-98* (Beaulieu et al., 2000). This report presents data from physical habitat and geomorphic measurements taken at 11 stream reaches from 1995-1998. In addition, the extent and type of dominant riparian vegetation along each reach were characterized.

EMAP Western Pilot Study – EPA created the Environmental Monitoring and Assessment Program (EMAP) Program to develop tools to monitor and assess the status and trends of national ecological resources. The primary goal of the EMAP Western Pilot Study is to generate state and regional scale assessments of ecological resources in 13 western states (including Arizona) and to identify stressors associated with the degradation of these resources. Beginning in 1999, this 5-year effort is to demonstrate the application of these monitoring and assessment tools across a large geographical area in western United States.

In Arizona, 50 sites will be sampled once during a four year period. A probability-based sampling approach is used to monitor the ecological condition of surface waters. Perennial, wadeable streams will be monitored for environmental indicators of pollutant exposure and habitat condition, including:

- aquatic macroinvertebrate, fish, and periphyton assemblages
- water quality
- physical habitat structure and riparian condition

In addition, the following indicators may be added depending on local importance and resource availability: fish tissue, priority pollutant toxic chemicals, water chemistry toxicity, sediment metabolism, sediment chemistry,

sediment toxicity, amphibians or bird tissue, bacteria, biomarkers (e.g. caffeine), and riparian conditions.

Because random selection of sites support statistical analysis and inferences, EMAP is designed to:

- Identify broad scale associations;
- Estimate the condition of wadeable perennial streams;
- Estimate the percent of stream miles having desirable and good condition;
- Strengthen statewide water quality and biological assessments; and
- Identify potential reference conditions.

It will not demonstrate localized cause and effect relationships or show trends in water quality. Further information about this project is available on EPA's website at: <http://www.epa.gov/emap/>.

Perchlorate Study – In 1999, a total of 112 perchlorate samples were collected to determine the occurrence of perchlorate in Arizona. These samples were collected by the Arizona Small Utilities Association and City of Phoenix staff for three site categories:

- Sites where perchlorate had been detected in 1998 by EPA monitoring (in Lake Mead, along the Colorado River to Yuma, at several locations along the Central Arizona Project (CAP) canal),
- Wells and surface water near potential sources of perchlorate (e.g., wells injecting CAP water, the San Pedro River near St David, Camp Navajo well, Luke Air Force Base well, Lake Mary and Woody Mountain Treatment Plant in Flagstaff), and
- Drinking water wells and surface water sources used by the Phoenix municipal system (e.g., Lake Pleasant, Central Arizona Project canal, Salt River, Verde River, and wells).

In an earlier study, perchlorate had been found in Lake Mead and downstream in the Colorado River at Yuma and in the Central Arizona Project canal at Lake Havasu. This perchlorate (ammonium perchlorate) stems from activities including a 1988 explosion at a rocket fuel plant near Henderson, Nevada and subsequent movement of the chemical down the Las Vegas Wash into Lake Mead.

Perchlorate is exceedingly mobile in water and can persist for many decades. Perchlorate is manufactured for use in solid propellants for rockets, missiles and fireworks. Perchlorate salts are used to inflate air bags, in nuclear reactors and electronic tubes, as additives in lubricating oils, in tanning and finishing leather, as a component in fabrics and dyes, in electroplating, in aluminum refining, in rubber manufacture, and in the production of paints.

No drinking water, ground water, or surface water quality standards exist for perchlorate. Arizona's Department of Health Services has calculated a health guidance level for drinking water at 31.5 µg/l (parts per billion) for adults and 14 µg/l for children. Both of these calculations include a safety factor.

Perchlorate values in surface water samples in Arizona ranged from 8.5 µg/l to less than detection limit of 4 µg/l. The highest level was found in Lake Mead near the Kingman Wash Bay. Perchlorate was not detected in any ground water samples (less than 4 µg/l).

ADEQ continues to closely monitor the perchlorate situation in Arizona. Beginning in 2001, all community water systems serving more than 10,000 people will monitor for perchlorate.

MTBE Study -- In 1998, a study of possible ground and surface water contamination by methyl tertiary butyl ether (MTBE) was initiated by ADEQ in cooperation with the USGS. Gasoline blends containing MTBE have been used in Phoenix and Tucson metro areas to help curb air pollution since 1989. Once released to the environment (due to spillage or storage tank leakage), MTBE has physical properties that cause larger areas of soil contamination and more persistent contamination than other gasoline components.

EPA currently concludes that there is a lack of information regarding health effects and occurrence of MTBE; therefore, a drinking water standard has not been established. However in 1997, EPA issued a Drinking Water Advisory that states that concentrations of MTBE in the range of 20 to 40 µg/L or below in water will probably not cause unpleasant taste and odor for most people. The Arizona Department of Health Services (ADHS) has established a health-based guidance level for MTBE in drinking water at 94 µg/L. ADEQ also established a Soil Remediation Level of 320 mg/kg in residential areas and 3,300 mg/kg in non-residential areas.

Samples were collected from 20 public water systems serving over 10,000

people and a number of Salt River Project production wells in Maricopa County. ADEQ also looked at samples collected between 1994-2001 by public water systems serving smaller populations and other wells in Maricopa County. This data indicates only a small number of MTBE detections between 0.5-19 µg/L (under guidance levels established by EPA or ADHS). Public water systems continue to monitor for MTBE and ADEQ plans to sample wells in the Phoenix AMA for a wide range of parameters, including MTBE; however, the sampling dates have not yet been established.

The Lakes Program has also monitored of drinking water reservoirs to determine whether watercraft exhaust and spills associated with refueling has caused water contamination. Samples have been collected at 5 reservoirs from January -August 2001. A preliminary review of this monitoring reveals that MTBE concentrations are all below 20 µg/L.

More information on MTBE is available at ADEQ's Web Site:
<http://www.adeq.state.az.us/comm/download/waste.html> (MTBE Report).

University Research Projects –

- Autecology and Restoration of *Sporobolus wrightii* Riparian Grasslands in Southern Arizona – In 1999, Arizona State University completed a study of the natural processes allowing for regeneration and maintenance of *Sporobolus wrightii* (giant sacaton) riparian grasslands along rivers in southern Arizona. This information will be used to determine the natural recovery and restoration potential of this type of community on abandoned agricultural fields located along these alluvial river systems.
- Quantifying Anti-erosion Traits of Stream Bank Graminoids – In 1997, Arizona State University completed a study of the physical traits of stream side grasses and grass-like plants (graminoids) to determine their potential capacity to stabilize stream banks. The study sites were located on Cienega Creek in Pima County. The study looked at grasses and graminoids in terms of their erosion prevention effectiveness for stream restoration and bank stabilization projects.
- Response of Bebb Willow to Riparian Restoration – In 1999, Northern Arizona University studied what happened when water flow was restored through a decadent Bebb willow ecosystem. The response of the plant community to water flow was quantified and compared. The project was intended to improve understanding of the structure,

function and dynamics of a watershed and its associated terrestrial and riparian ecosystems.

- Evaluation of *Carex* Species for Use in Riparian Restoration – Northern Arizona University was awarded a Watershed Protection Grant to develop transplant guidelines for the use of sedges in riparian restoration projects. The project is to:
 - a. Evaluate the performance of transplanted plugs of various sizes and species of sedges under three different grazing regimes,
 - b. Quantify the herbaceous species composition and arrangement, of grazed and ungrazed plant communities at two study sites,
 - c. Evaluate the effects of water stress and grazing on transplanted plugs of sedges under greenhouse conditions.
 Two montane riparian sites will be evaluated in the Coconino National Forest: Hoxworth Springs and Buck Springs.

Congressional Western Water Policy Review Advisory Commission – In 1992, Congress established a commission to undertake a comprehensive review of federal activities in the nineteen Western states (including Arizona) which may affect the allocation and use of water resources. A final report, including their recommendations was completed in 1998. In this report, the commission proposes principles by which any federal water program should be guided or judged against. These principles were:

- (Primary) Ensure sustainable use of resources
- Maintain national goals and standards
- Emphasize local implementation, innovation, and responsibility
- Provide incentives to achieve goals
- Respect existing water rights and appropriation systems
- Promote social equity
- Organize around hydrologic systems
- Translate goals to measurable objectives, assess performance through sound science, and where knowledge is incomplete use adaptive management.
- Employ participatory decision making
- Promote innovative funding

Proper Functioning Condition of Riparian and Wetland Areas -- ADEQ has also been working with US Forest Service and the Bureau of Land Management to establish a repository for riparian area Proper Functioning Condition data, including a graphic display of sites and riparian conditions. In 2000,

information from 517 sites were processed.

The US Geological Survey – The mission of the U.S. Geological Survey is to assess the quantity and quality of the earth resources of the Nation and to provide information that will assist resource managers and policy makers in making sound decisions. Assessment of water quality conditions and trends is an important part of this overall mission. Therefore, the U.S. Geological Survey publishes numerous reports and fact sheets about water-related resources in Arizona. Some of the recent publications of note include:

- *Ground Water Resources for the Future – Desert Basins of the Southwest* (Leake et al., 1999) is a fact sheet about the occurrence of ground water and consequences of ground water use.
- *Arsenic in Ground Water Resources of the United States* (USGS, 2000) is a fact sheet showing that most of Arizona has naturally high levels of arsenic and how the probable change in drinking water standards may affect public water systems.
- *Pesticides in the Atmosphere* (Majewski and Capel, 1995) is a fact sheet about the current understanding of how atmospheric deposition influences the distribution of pesticides.
- *A National Look at Nitrate Contamination of Ground Water* is a fact sheet published in the *Conditioning and Purification Magazine* (Nolan, et al, 1999) describes how USGS scientists have been able to map high and low risk areas of the nation for nitrate contamination.
- *Pesticides in Surface Waters* (Larson et al., 1997) is a fact sheet summarizing national and regional occurrence of pesticides in surface waters. It also looks at limitations in assessing the significance of pesticides in surface waters.
- *Pesticides in Stream Sediment and Aquatic Biota* (Newell et al., 2000) is a fact sheet summarizing the distribution of contamination, sources, trends, environmental fate, and biological significance.
- *Where do the Salts Go?* (Cordy and Bouwer, 1999) is a fact sheet looking at the potential effects and management of salt accumulation in south-central Arizona.
- *Occurrence and Quality of Surface Water and Ground Water within the Yavapai-Prescott Indian Reservation, Central Arizona, 1994-1998* (Littin, et al, 2000) summarizes water quality on this 1,395 Indian Reservation, identifies limitations for designated uses, and discusses potential for contamination from point and nonpoint sources.

- *Ground Water Quality in Alluvial Basins that have Minimal Urban Development, South-Central Arizona* (Gellenbeck and Coes, 1999) summarizes data from 772 wells in 16 alluvial basins with minimal urban development as a baseline to which water quality problems associated with urbanization can be compared.
- *Depth Profiles of Temperature, Specific Conductance, and Oxygen Concentration in Lake Powell, Arizona-Utah, 1992-95* (Marzolf, et. al., 1998) reports on the measurements that establish vertical-density gradients that regulate the distribution of a wide array of chemical and biological features in the lake.
- *Determination of Channel Change for Selected Streams, Maricopa County, Arizona* (Capesius and Lehman, 2002) reports on the lateral and vertical change in the channel on seven stream sites with 10 to 30 years of record.
- *Daily and Seasonal Variability of pH, Dissolved Oxygen, Temperature, and Specific Conductance in the Colorado River Between the Forebay of Glen Canyon Dam and Lees Ferry, Northeastern Arizona, 1998-99.* USGS in cooperation with the Grand Canyon Monitoring and Research Center reports on the range of variation of these parameters as indicators of trophic productivity for the trout fishery occurring in this reach.
- *Computed Roughness Coefficients for Skunk Creek Above Interstate 17, Maricopa County, Arizona* (O'Day and Phillips). The USGS in cooperation with the Maricopa County Flood Control District established a stream channel roughness coefficient for Skunk Creek, based on flows ranging from 187 to 760 cfs, that can be transferred to similarly vegetated channels in arid and semiarid environments for flood management or other purposes.

Copies of these publications can be obtained by contacting the USGS at (502) 607-6671.

US Forest Service and Bureau of Land Management – Both agencies are guardians of public lands, and work to sustain the health, diversity and productivity of public lands for the use and enjoyment of present and future generations. To support this effort, several important guidance documents have been prepared.

- *Stream Channel Reference Sites: an Illustrated Guide to Field Techniques* (Harrelson et al., 1994). This document provides a guide

to establishing permanent reference sites for gathering data about physical characteristics of streams and rivers.

- *A Framework for Analyzing the Hydrologic Condition of Watersheds* (McCammon et al., 1998). The Bureau of Land Management and US Forest Service collaborated on this guidance document to provide a national framework for hydrologic analysis and a comprehensive interdisciplinary watershed analysis. The guidance outlines a process for identifying the essential factors to describe hydrologic condition from a vast array of possible factors.
- *Riparian Area Management -- Process for Assessing Proper Functioning Condition* (BLM, 1993) documents a process for assessing the physical function of a lotic (flowing water) ecosystem and the associated riparian or wetland area.
- *Riparian Area Management -- Process for Assessing Proper Functioning Condition for Lentic Riparian-Wetland Areas* (BLM, 1999). This guidance modifies the process for assessing lentic systems (open waters such as lakes and marshes).
- *Riparian Area Management -- Process for Assessing Proper Functioning Condition for Lotic Riparian-Wetland Areas* (BLM, 1998). This guidance modifies the process outlined in 1993 for assessing lotic systems (flowing water).
- *Riparian Area Management -- Grazing Management for Riparian and Wetland Areas* (BLM, 1997) provides Best Management Practices for grazing to protect riparian and wetland areas.
- *Management for Enhancement of Riparian and Wetland Areas of Western United States* (BLM and USFS, 2000). This document provides Best Management Practices to preserve riparian and wetland areas in the Western United States.

The US Fish and Wildlife Service -- The USFWS is committed to working to conserve, protect, and enhance fish, wildlife, and plants and their habitats for the continuing benefit of American people. Most current USFWS reports are included in the following watershed discussion; however, one recent publication has a national perspective.

- *Status and Trends of Wetlands in the Conterminous United States 1986 to 1997* (Dahl, 2000) estimates the net loss of wetlands and the annual rate of loss, compares this rate to previous estimates, and attributes wetland losses and gains to land activities and federal, state, and local protective actions.

- *Contaminants in Potential Aplomado Falcon Prey from Proposed Reintroduction Sites in Arizona* (King, et al, 1995) reports on the concentrations of organochlorine compounds (historically used pesticides) and metals found in Aplomado falcon prey species (meadowlarks, mourning doves, lizards, and grasshoppers collected near Fort Huachuca and in San Simon Valley, the San Pedro Riparian National Conservation Area, San Bernadino/Leslie Canyon National Wildlife Refuge, and Empire Cienega Ranch.
- *Contaminants in Southwestern Willow Flycatcher Eggs and Prey Items, Arizona, 1998-2000* (King, et al, 2002) documents concentrations and potential effects of organochlorine compounds (historically used pesticides) and metals in added eggs and potential prey of the endangered southwestern willow flycatcher collected at 10 Arizona breeding areas and one area in California.

United States and Mexico Border Issues -- The United States - Mexico border Field Coordinating Committee of the U.S. Department of Interior has published a series of fact sheets summarizing significant issues related to shared water resources along the United States and Mexico border.

- *Water Resources Issues in the Mexican Highlands Subarea* (U.S. - Mexico Border Field Coordinating Committee, 1997) looks at issues along the eastern half of Arizona on both sides of the border.

The US Environmental Protection Agency -- Numerous national water quality assessment guidance documents have been published by EPA, whose mission is to protect human health and safe guard the natural environment. Some of the important documents are available at EPA's website: www.epa.gov/owow. Recently published documents include:

- *2002 Integrated Water Quality Monitoring and Assessment Report Guidance* (November 2001) recommends that states provide a combined report that fulfills requirements of the Clean Water Act sections 305(b) and 303(d), and indicates the information that must be included in such a submission.
- *Draft Consolidated Assessment and Listing Methodology – Toward a Compendium of Best Practices* (USEPA, 2001) outlines a process to improve state monitoring and assessment programs.
- *Guidance for Assessing Chemical Contaminant Data for use in Fish Advisories. Volume 1-- Fish Sampling and Analysis. Volume 2 -- Risk*

assessment and fish consumption limits. Third edition. These two volumes provide methods for determining whether a fish advisory is necessary.

- *Stressor Identification Guidance Document* (USEPA, 2000) provides a formal and rigorous process that identifies stressors causing biological impairment in aquatic ecosystems and provides a structure for organizing the scientific evidence supporting the conclusions.
- *Rapid Bioassessment Protocols for Use in Wadeable Streams and Rivers – Periphyton, Benthic Macroinvertebrates, and Fish* (USEPA, 1999) is a practical technical reference for conducting cost-effective biological assessment of lotic (flowing water) systems.
- *Nutrient Criteria – Technical Guidance Manual, Lakes and Reservoirs* (Gibson et al., 2000). This document provides guidance for assessing nutrient related trophic state impairment of lakes and methods for developing region-specific nutrient criteria. Four basic indicators of over-enrichment are identified as: total phosphorus, total nitrogen, algal chlorophyll and Secchi depth. An essential part of the process for developing nutrient criteria is to pay attention to downstream effects.
- *Protocols for Developing Sediment TMDLs* (USEPA, 1999). This TMDL protocol was developed to provide a framework for establishing TMDLs for sediment, but do not address contaminants that may be associated with sediments. The process presented will assist with development of rational, science-based assessments and decisions, and should lead to the establishment of an understandable and justifiable TMDL.
- *Lake and Reservoir Bioassessment and Biocriteria – Technical Guidance Document* (USEPA, 1998). This document provides methods and approaches for adapting bioassessments and biocriteria to assess lakes. Methods range from lake trophic state surveys to detailed bioassessments and habitat measurements.

Federal Interagency Stream Restoration Working Group – Fifteen federal agencies and partners produced a common reference manual on stream corridor restoration (2000). A copy can be obtained through the US Department of Agriculture website: http://www.usda.gov/stream_restoration/

- *Stream Corridor Restoration* (Federal Interagency Stream Restoration Working Group, 2000). This document encourages locally lead, public involvement in restoration planning and implementation.

Colorado Basin Salinity Control Program – Damage estimates caused by excessive salinity in the Colorado River Basin in the United States typically range between \$500 million and \$750 million per year. Since the 1970s, Reclamation has been working with the U.S. Department of Agriculture, the Bureau of Land Management, and seven states in the Colorado Basin Salinity Control Forum to build and operate salinity control projects on the Colorado River that provide a cost-effective reduction in river water salinity.

In 1994, the Colorado River Basin Salinity Control Act was amended to direct that a comprehensive program be developed for minimizing salt contributions from lands administered by that the Bureau of Land Management (BLM). Successes with the resource base will translate to improved vegetation cover, better use of onsite precipitation, and stronger plant root systems, resulting in a more stable runoff regime and reduced soil loss. Further the US Department of Agriculture was authorized to:

- Identify salt source areas and develop project plans for salinity control;
- Provide financial and technical assistance to land users to plan, install, and maintain salinity reduction practices, including voluntary replacement of incidental fish and wildlife values foregone;
- Conduct research, demonstration, and education activities ; and
- Monitor and evaluate program effectiveness.

In 1995, the Bureau of Reclamation opened the selection of projects to a "Request for Proposal" competitive process. The average cost of salinity control has subsequently dropped from about \$70 per ton to \$30 per ton. New salinity control projects are funded by a one-time grant that is limited to the competitive bid. Once constructed, the facilities are owned, operated, maintained, and replaced by the sponsors at their own expense.

The Federal Agriculture Improvement and Reform Act of 1996 further amended the US Department of Agriculture's role in salinity control by creating a new conservation program known as the Environmental Quality Incentives Program, which combined four conservation programs including USDA's Colorado River Salinity Control Program.

Watershed Specific Assessment Information

The rest of this Volume II contains watershed specific information about water quality conditions in Arizona. For each watershed, the following information is provided:

- General information characterizing the watershed, including a map of land ownership, a map of land uses (NPDES permits, urban areas, mines);
- Surface water quality monitoring tables, an assessment table, and an assessment map illustrating monitoring sites and final assessments;
- Ground water quality information, including a monitoring tables and maps illustrating the information on the tables and monitoring distribution; and
- Studies and water quality improvement activities in the watershed.

Surface Water Monitoring Tables – The information in the surface water monitoring tables may be the most valuable information in this report. This information is the basis for 303(d) listing and delisting decisions, and this information is cited by many federal and state programs that permit activities that may add further discharges to these surface waters. These tables provide the most comprehensive list of monitoring activities in Arizona.

A summary line was added to these tables for this assessment. This shaded row summarizes all of the monitoring data collected in that surface water and indicates the designated use support for each use. The summary row shows all exceedances that were used as the basis for this assessment, excluding any exceedances that were specifically exempted.